

Advanced Power Electronics

Internal Permanent Magnet Reluctance Machine Utilizing Brushless Field Excitation

Background

Permanent magnet (PM) motors are quickly gaining acceptance as the “electric motor of choice” for hybrid and electric vehicle traction drives. This technology offers a higher power density motor with enhanced performance benefits over other motor types that have been previously considered for traction drive applications. However, technological and economic barriers still exist for this emerging technology.

Field weakening techniques are necessary to expand the speed range of the system. These often add complexity and increase the cost of the inverter. Additional techniques are necessary to enhance the starting torque. As motor speeds increase, the higher back EMF creates the need for boost converters to produce higher bus voltage, also adding to costs.

Technology

Through the addition of external excitation coils, the field of the motor can be both weakened and enhanced to negate these barriers. In a conventional PM machine, the air-gap flux produced by the magnets is fixed; it is difficult to enhance the air-gap flux density due to limitations of the permanent magnets in a series-magnet circuit. However, the air-gap flux density can be weakened by using field weakening techniques.

Researchers at the Oak Ridge National Laboratory (ORNL) have developed a technology that uses external excitation coils to enhance and weaken the air-gap flux density. This technology makes the ability to manipulate the field utilizing costly boost converters in the system unnecessary.

The potential exists for using weaker, less costly permanent



Figure 1. A permanent magnet motor.

Benefits

- Increases power density of the system.
- Decreases system size and weight.
- Eliminates the need for a boost converter in the system.
- Increases the reluctance torque component, resulting in a higher total torque output.
- Increases flux density in the motor.
- Reduces core losses at higher speeds.



magnets in the motor, resulting in additional significant cost savings. Minimal control circuitry and power is required to implement this technology.

Status

This effort is still in its early stages; the current design is being optimized. ORNL is working closely with U.S. auto manufacturers to ensure that the R&D of this technology is closely aligned with industry needs, providing a clear path to commercialization in the future.

Contacts

Laura D. Marlinio
ORNL Project Manager
Oak Ridge National Laboratory
(865) 946-1245
marlinold@ornl.gov

Susan Rogers
DOE Technology Manager
Department of Energy
(202) 586-8997
susan.rogers@ee.doe.gov

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.